NERL Research Abstract

EPA's National Exposure Research Laboratory
GPRA Goal 1 - Clean Air
APM # 444

Significant Research Findings

New Receptor Models for Particulate Matter$_{2.5}$ Source Apportionment

Scientific Problem and Policy Issues

Regions of the U.S. that are not in compliance with National Ambient Air Quality Standards (NAAQS) for particulate matter (PM_{10} or $PM_{2.5}$) are required to develop source emissions control strategies. Such strategies depend on estimating the contributions of individual source emissions to PM concentrations in the ambient air in order to better target sources for reduction efforts. The traditional tools for making these estimates have been mathematical air quality simulation models (AQSMs), coupled with emissions inventories and likely meteorological scenarios. Difficulties with this approach include the inability of any AQSM to capture the full complexity of pollutant transport and transformation in the atmosphere, and the uncertainties of emissions rates taken from existing emissions inventories. An alternative to this source-oriented approach is a receptor-oriented one, as embodied in air quality receptor models. Receptor models are mathematical procedures for identifying and quantifying the sources of ambient air pollutants at a site (receptor), primarily on the basis of the concentrations of source-tracing chemical species measured at the receptor and generally without need of emissions inventories and meteorological data. Receptor models are the natural complement to AQSMs, and have begun to be used in State Implementation Plans (SIPs) for achieving NAAQS compliance.

Research Approach

Two different receptor modeling approaches were selected for development and/or improvement under this project: a chemical mass balance (CMB) and a multivariate approach. The two differ greatly in their complexity and their domains of applicability. The CMB approach requires as data the chemical profiles of potential contributing sources and the corresponding chemical data from measurements performed on a single ambient air sample. In contrast the input data required by a multivariate approach are chemical measurements from many (hundreds) of ambient air samples which are mathematically manipulated simultaneously. It is a more complex approach, but its great potential advantage is that chemical profiles of the sources are not required; instead, they are generated from the ambient data themselves. The CMB approach has been

supported by EPA's Office of Air Quality Planning and Standards (OAQPS) for more than a decade in the form of the DOS-based software module CMB7. Work under this project was intended to update CMB7 by converting it to a Windows-based application, improving its usability, and correcting known errors.

The particular multivariate approach chosen for this project is based on a form of Factor Analysis, but its novelty is that physically-meaningful constraints are imposed which are intended to remove the undesirable ambiguity of the multiple solutions that are characteristic of ordinary Factor Analysis.

Results and Implications

The two models that have resulted from this project are EPA-CMB8.2 and UNMIX (named for its function, which is to "unmix" the concentrations of chemical species measured in the ambient air to arrive at the magnitudes of the underlying sources). A software module and accompanying user's manual for each model are now available. These tools advance the viability of the receptor modeling approach to air pollution control. The availability of standardized versions of these two receptor models is expected to facilitate their use throughout the air pollution research and regulatory community, and to facilitate the intercomparison of results derived from different data sets. Both models should be usable on data generated from EPA's new 300-site $PM_{2.5}$ Speciation Network, with UNMIX particularly well-suited because of its large data volume requirement.

Research Collaboration and Publications

The development of the CMB8 software was done under contract, initially with the Desert Research Institute and subsequently with Pacific Environmental Services, Inc. Both efforts received the collaborative support (funding, administrative, and technical) of EPA's Office of Air Quality Planning and Standards (OAQPS) and NERL. The present version of the CMB8 software is described in

Coulter, T., Wagoner, R.A., Lewis, C. W. Chemical Mass Balance Software: EPA-CMB8.2. Submitted for inclusion in Proceedings of the AWMA/EPA Symposium, Measurement of Toxic and Related Air Pollutants, September 12 - 14, 2000, Research Triangle Park NC. 2000.

UNMIX software development was performed at the University of Southern California, through a combination of cooperative agreements and contract support. An initial evaluation of UNMIX occurred during an EPA-sponsored workshop held during February, 2000 as described in the following publication.

Willis, R. D. Workshop on UNMIX and PMF as Applied to $PM_{2.5}$; June. Report no. EPA/600/A-00/048. 2000.

Future Research

Because of the complexity of these models, particularly UNMIX, the small amount of evaluation performed thus far is promising, but is inadequate to establish whether either can be regarded as deserving of EPA's official endorsement as a regulatory tool. Evaluation will continue in the form of their application to data from various field research studies and monitoring networks, such as the new Super Sites program and the $PM_{2.5}$ Speciation Network. The experience and understanding gained from these applications, along with peer review of the resulting publications, is expected to culminate in a decision on whether the models will receive EPA's endorsement.

Questions about NERL's source apportionment/receptor modeling research may be directed to:

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